

Nematophagous fungi: *Metarhizium anisopliae*

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Abstract— Plant-parasitic nematodes are major pests affecting many economically important crop productions throughout the world. Some chemicals are widely used against the phytonematodes. Because of hazardous effects of these compounds on human beings, animals and on the environment, there is a need to develop other control strategies. Biocontrol of phytonematodes is an important method among environment-friendly measures of nematode management. There are some soil-inhabiting fungi that have biocontrol potential on phytonematodes, which can be used for nematode management. The fungus *Metarhizium anisopliae*, originally is an entomopathogenic bioagent has been utilizing as bionematicides. The fungus produces some secondary metabolite which may play a role in pathogenicity. Biocontrol potential of this fungus on some phytonematodes has been reported and its utilization is a major approach towards sustainable and environment friendly agricultural production.

Keywords— Plant-parasitic nematodes, bionematicides, nematophagous fungi, *Metarhizium anisopliae*, entomopathogenic fungi.

I. INTRODUCTION

Plant parasitic nematodes are one of the major factors limiting the productivity of many agricultural crops (Luc *et al.*, 2005). The majority of the synthetic chemical nematicides are being banned in the market because of their hazardous effect on human beings and animals (Ghazalbash and Abdollahi, 2011). Therefore there is a need for sustainable, effective, and environmentally acceptable nematode management options (Sikora and Fernandez, 2005). Large numbers of organisms including fungi, bacteria, viruses, insects, mites and some invertebrates have been found to invade or prey on the nematodes (Stirling, 1991). Some soil inhabiting fungi are pathogenic to some pests of plants, including insects and nematodes (Dijksterhuis *et al.*, 1994). Fungi have a significant association with nematodes in rhizosphere and thus, they can constantly reduce the population of nematodes in nearly all soils in different geographical areas (Siddiqui and Mahmood, 1996). Although more than 70 genera and 160 species of fungi have been associated with nematodes, only

a few of them are known as nematophagous fungi (Duddington, 1994). Fungi can directly parasitize nematodes (Holland *et al.*, 1999; Olivares Bernabeu and Lopez-Llorca, 2002; Chen and Chen, 2003; Fatemy *et al.*, 2005) or secrete nematicidal metabolites and enzymes that affect nematode viability (Cayrol *et al.*, 1989; Nitao *et al.*, 1999; Chen *et al.*, 2000). These active compounds have the potential for being applied as novel nematicides (Meyer *et al.*, 2004).

II. NEMATOPHAGOUS FUNGI: *METARHIZIUM ANISOPLIAE*

Metarhizium anisopliae, the agent of green muscardine disease of insects, formerly known as *Entomophthora anisopliae* (basionym) (Metschnikoff, 1879), is a fungus that grows naturally in soils throughout the world and causes disease in various insects by acting as a parasitoid. It is the most important entomopathogenic fungus (Richards and Rogers, 1990; Driver *et al.*, 2000; Liu *et al.*, 2007; Hoe *et al.*, 2009). *Entomophthora anisopliae*, later on renamed to *M. anisopliae* by Sorokin (1883). The fungus has mass growth on artificial culture media and produces abundant conidia, but the conidia only germinates in contact with their host (Farashiani *et al.*, 2011).

III. MODE OF ACTION AND EFFECTS ON NEMATODES

The exact mode of action of *M. anisopliae* on nematodes is still unknown but it is likely similar to other fungi with sticky spores or conidia. The conidia germinate, parasitize and kill the cadaver, by direct penetration and producing the infective hyphae inside the nematode body. Prior to any direct attack to the host, the fungus produces destruxin A and destruxin B that can kill the host (Roberts, 1966). Kershaw *et al.*, 1999 and Hsiao and Ko (2001) reported that this fungus produces some cyclic peptides, destruxins which may play a role in its pathogenicity. There are a few reports on impact of *M. anisopliae* on nematodes. Biological control of sugarcane nematodes using *Penicillium oxalicum* and *M. anisopliae* has been studied by Zorilla (2001). He has reported the significant inhibitory effect of *M. anisopliae* on the studied nematode population. The effect

of this fungus against *Rotylenchulus reniformis* have been reported by Tribhuvaneshwar *et al.*, (2008). They have reported that application of this bioagent reduced the final population of this plant parasitic nematode as well as some species of free-living nematodes. In a survey in Boyer-Ahmad region in Iran, some naturally infected nematodes to *M. anisopliae* were observed (Ghayedi and Abdollahi, 2013). They purified the isolated fungus and also they showed the biocontrol potential of the isolate on J₂s of *Heterodera avenae*, with 47.1% parasitization. Biocontrol potential of *M. anisopliae* against some species of root knot nematodes has been shown (Jahanbazian *et al.*, 2014; Jahanbazian *et al.*, 2015). Greenhouse investigations showed that both bioagents *Trichoderma harzianum* and *M. anisopliae* caused significant decrease in nematode related factors including root gall, but the inhibition in root galling of tomato was more in case of *M. anisopliae* (Khosrawi *et al.*, 2014).

IV. BIO-PRIMING EFFECTS OF *M. ANISOPLIAE*

The capability of microorganism to colonizing the roots of plant is an important factor to have the promoting power (Schroth and Hancock, 1982). Some species of *Metarhizium* are attracted to roots of certain plant species (Wang and St Leger, 2007) and has root colonization ability (Bruck, 2005). Conidial germination and different rates of root colonizing by *M. anisopliae* isolates, has been reported (Elena *et al.*, 2011; Sassan *et al.*, 2012). Even some isolates of *M. anisopliae* have endophytic behavior (St. Leger, 2008). Bio-priming effects of *M. anisopliae* on germination and seedling growth of flax seed have been shown by Bakht *et al.*, (2015). The number of galls, egg masses and eggs of *M. javanica* were reduced in tomato roots by soil application of *M. anisopliae* spore suspension along with oak debris. The tomato roots have been colonized by *M. anisopliae* and the rate of nematode penetration to the roots was declined. Based on their reports, the growth of infected tomato plants has been improved after application of *M. anisopliae* (Abdollahi, 2018).

V. CONCLUSION

For a sustainable nematode management we have to isolate, mass produce and formulate the virulent strains of *Metarhizium anisopliae* which are environment friendly as well as cost effective. In near future *M. anisopliae* will provide a promising bionematicide which in turn improve plant growth and increase crop yield.

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